Identification of Access Elements for Safety Analysis Using Aerial Photography

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GIS-T

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USDOT Remote Sensing Initiative

- NCRST – Infrastructure
  - University of California, Santa Barbara (Lead), University of Wisconsin, University of Florida, Iowa State University
- Sponsored by
  - USDOT, RSPA
- In cooperation with NASA
- Matching funds, Iowa DOT

Introduction

- One person dies every 13 minutes (all crashes)
- Economic Cost
  - ➢Crashes in US - $150.5 billion/year (1994)
  - ➢Congestion – $72 billion/year (For 68 major Metropolitan areas in U.S.A)
- One cause: poor management of access

Source: BTS,TTI

Objectives

- Enable the increased application of access management using remote sensing to …
  - ➢Reduce cost of site specific access studies
  - ➢Facilitate cost effective systematic ID of problem areas
- See if RS data can be used in crash prediction models

Access Management

"… provide access to land development while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity, and speed".

(Source: Federal Highway Administration, United States Department of Transportation)

Remote sensing

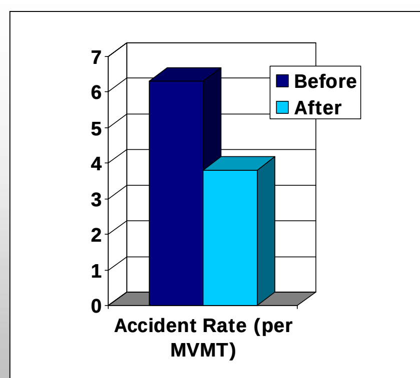
- "the use of electromagnetic radiation sensors to record images of the environment, which can be interpreted to yield useful information"
- Types of remote sensing
  - Satellite imagery
  - Aerial photography

What are the Benefits of Managing Access?

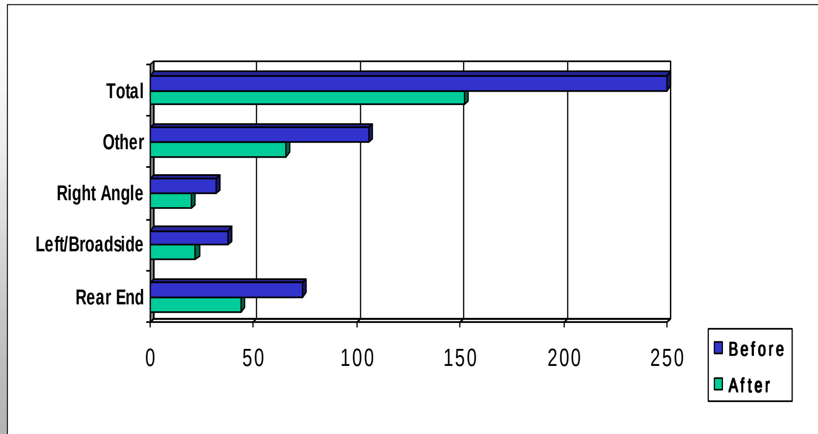
- Improved safety to motorists
  - Reduction in crashes and crash rates
- Improved traffic operations
  - Increased traffic level of service, capacity, and travel speed
- Safety and operational benefits for pedestrians, bicyclists, and public transit buses
- Lower overall costs for taxpayers
- Improved air quality

Safety Benefits: Iowa Case Studies

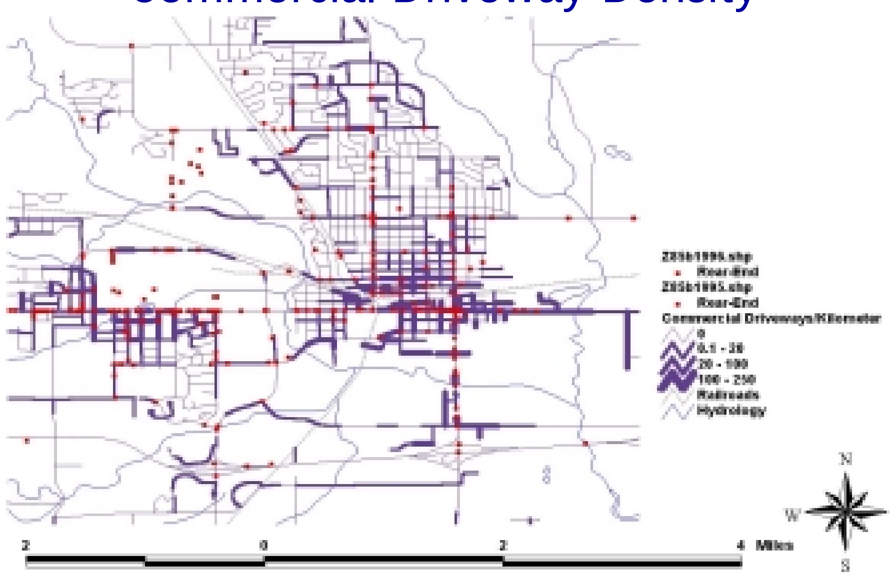
- Seven Iowa case studies were made on a "before and after" basis
- Case studies show nearly a 40 percent average reduction in accident rates after projects incorporating access management treatments were completed



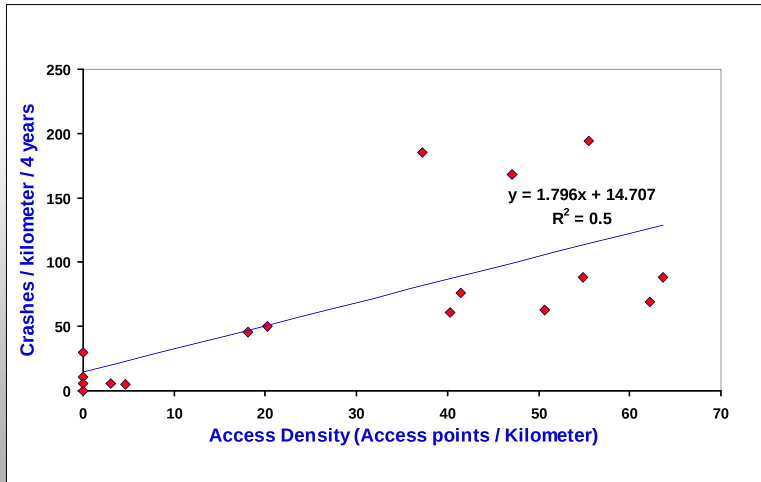
Safety Benefits: Crash Reduction By Type For Iowa Case Studies



Rear-end Crashes and Commercial Driveway Density



Mid-Block Crash Density vs. Access Control (Driveway Density)



Access Related Crashes

- Colorado 52%
- Oklahoma 57%
- Michigan 55%

Source: ITE

Research Problem

- Access studies typically done only on case by case basis
- Why? data collection is
  - time consuming
  - resource intensive
- Therefore ... no easy way to systematically ID priority areas for improvement

Research Approach

- Survey DOTs
- Identify data required for crash prediction models
- Collect data (and assess) by remote sensing
- Run models
- Identify priority areas for improvement of access control
- Comment on utility of entire process

Survey of State DOTs

- 10 state DOTs (8 responded)
  - – Florida -- Kansas
  - – South Dakota -- Wisconsin
  - – Michigan -- Colorado
  - – Oregon -- Minnesota
- Questions
  - ➢ Access management data elements collected
  - ➢ Method of collecting data

Survey of State DOTs

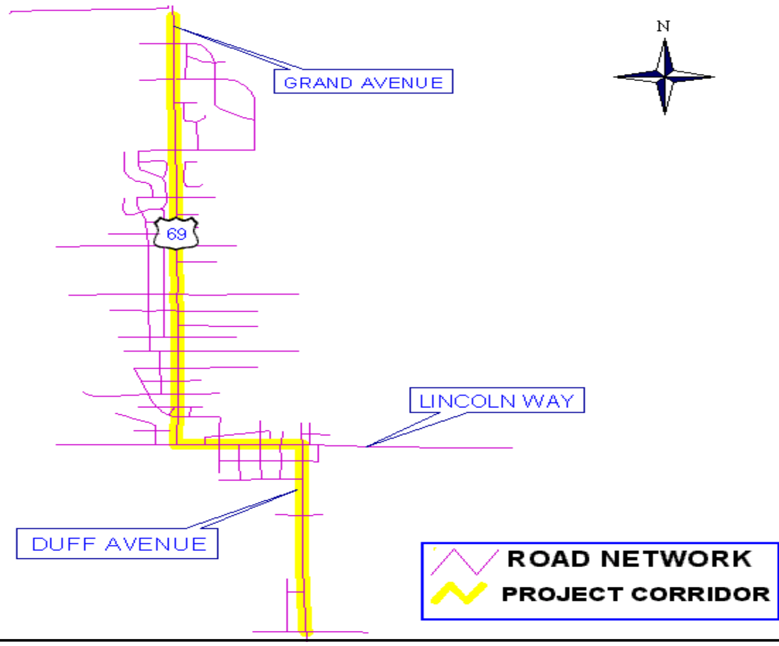
- None maintain a comprehensive database of access related data elements
- Usually collect data as needed (corridor level)
- Several
  - ➢ are in the process of developing one or
  - ➢ have indicated an inclination towards maintaining one.

DOT	Data collection methods	Comments
Florida	Video logging and surveying	Driveway locations are collected if part of an improvement project or permit.
Kansas	GPS receivers	The access database is being developed. KDOT is investigating the option of utilizing aerial imagery for data validation and display.
South Dakota	Plan sheets from construction projects	Aerial photography is used extensively during planning and project development, but not as a data collection tool for access management.
Wisconsin	Photo logs and from driveway permits	Aerial photography is only used for route layout and design, but not as a data collection tool for access management.
Michigan	Video logs	Does not maintain information related to access on an annual basis.
Colorado	Video logs	**Aerial imagery is used to identify access locations and circulation alternatives.**
Oregon	Video logs and Manual Data collection	Aerial photography and satellite imagery are used for spatial data collection.
Minnesota	Field inventory, Video logs and from as built records	The methods mentioned are project specific. Currently there is no existing system to record access permits.

Identify data required for crash prediction models

- Select statistical access management/crash model
  - Other research organizations
  - Crash frequency are f(#commercial driveways, median type, etc.)
- 17 study segments
  - US 69 corridor in the city of Ames, IA

Project Corridor



Data required

- Identify access-management related features required by crash models
- Model Form:

$$E(\wedge) = a_1 \times L^{a_2} \times V^{a_3} \times e^{\sum_{i=1}^{n} b_i x_i}$$

where

$E(\wedge) =$ predicted accident frequency

$\mathrm{L} =$ segment length

$V =$ annual average daily traffic (AADT)

$\mathrm{x_i} =$ additional variables in the models

$\mathrm{a_1, a_2 . a_3, b_i}$ are model parameters

Access Related Data Elements

- Driveways
  - Number
  - Dimensions
  - Spacing
  - Land Use
  - Continuity
  - Vertical grade
- Access roads
  - Presence
  - Configuration
- Medians
  - Presence
  - Type
  - Length
- Turn lanes
  - Length
  - presence
- Intersections
  - Type
  - Frequency
  - Proximity

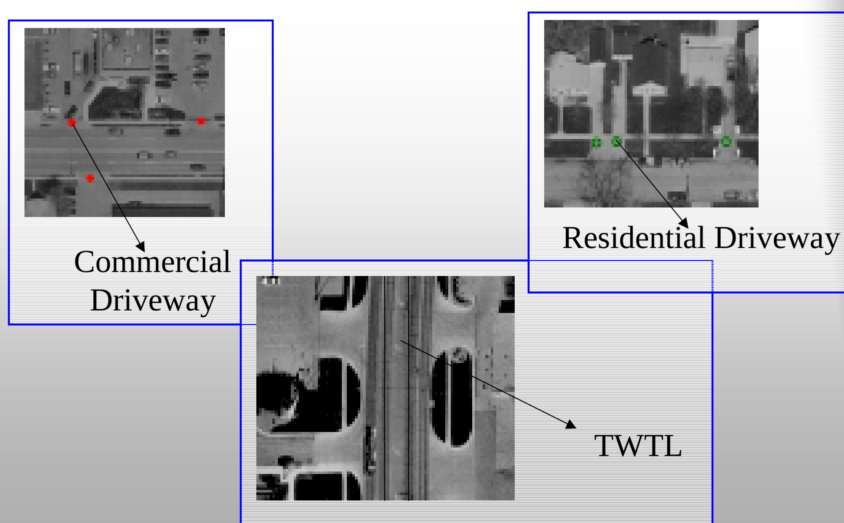
Use of Remote Sensing

- Extract access-management related elements
  - Evaluate aerial photographs at different resolutions
  - Make recommendations on level required

Data

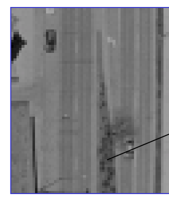
- Aerial Images
  - 6-inch pixel, panchromatic (Iowa DOT)
  - 2-foot pixel, panchromatic (Story county engineer's office)
  - 1 meter
- Crash Data
  - Iowa Department of Transportation
- Attributed Road network
  - AADT
  - Speed Limit

Data Extraction

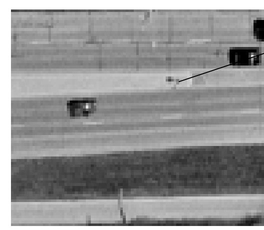


Identifying Medians

- Look for object markers along the center of the Road.
- Object markers are an important source of identifying the type and length of raised medians
- Pavement markings
- Depressed medians can be identified with ease as most of them are covered with Vegetation



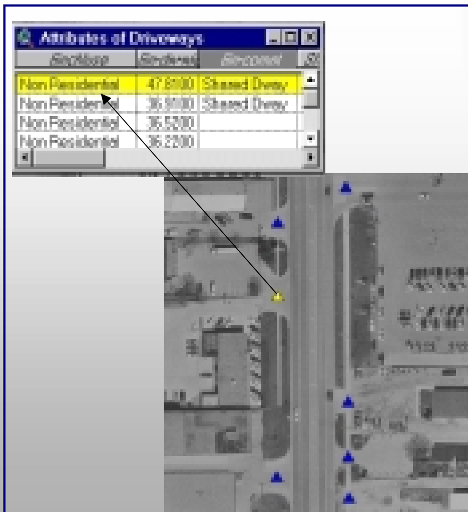
Raised Median



Object marker

Identifying Driveways

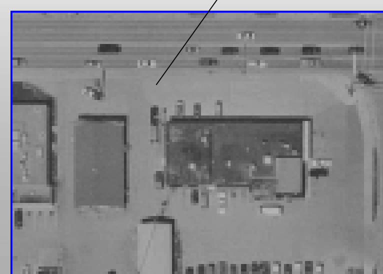
- Sharp difference in shade from the surrounding area
- Cuts along the curb
- Vehicular movement captured at the time of taking the photograph and parked vehicles may also be used as a source to identify driveway entrances
- Problems
    - Tree Cover (Dense Vegetation)
    - Several close driveways appear as one



Results

- 2 feet and 1 meter images
  - > 20% error rate)
- 6 inch resolution images
  - < 3% error rate)

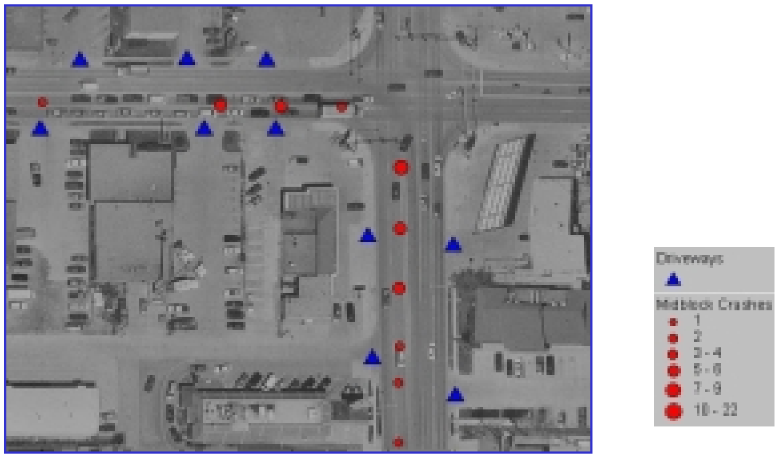
Where is the driveway?



Measurement Accuracy

- 31 Driveway Widths Measured
- 6 inch Panchromatic Aerial Orthophotos
- Field measurement is “truth”
- Mean error ~9 inches
- Standard error ~ 1 inch

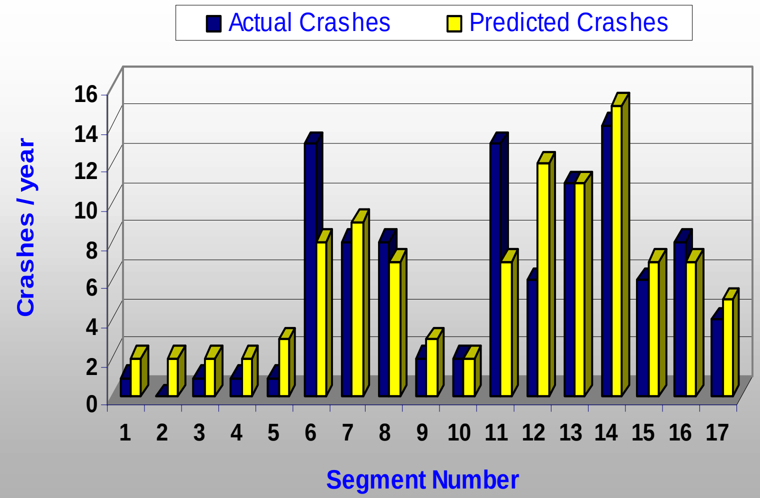
Safety Analysis



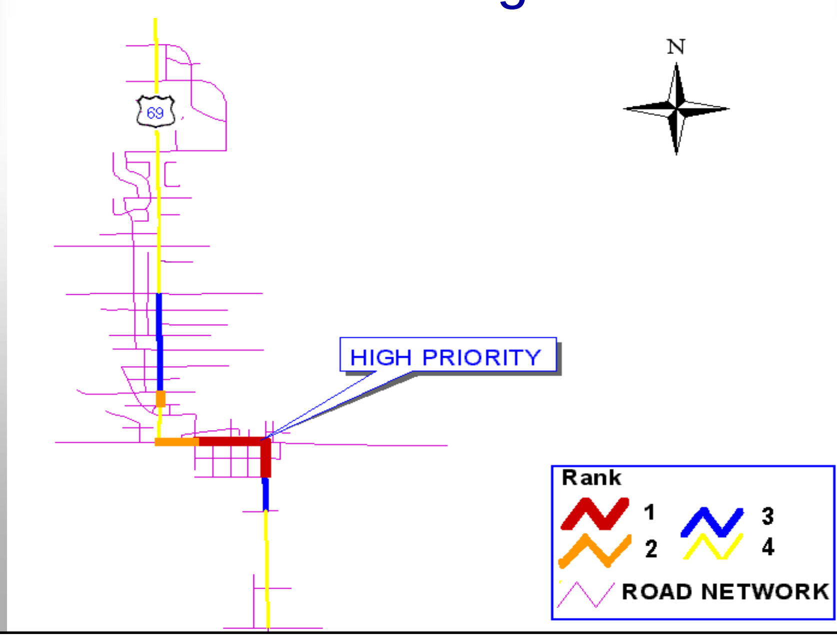
Safety Analysis

- Run models with RS data
- Compare outputs to known crash frequency
- Choose best performing model, adjust parameters for best fit
- Use model to forecast crashes
- Prioritize segments for improvement

Predicted Vs Actual Crashes



Prioritized Segments



Conclusions (so far)

- For all models tested ...
- Remotely sensed data produce same result (rank) as field collected data
- Costs ... field 10 hours, ortho's 5 hours, perhaps could be improved (scale, automation)
- 6" ortho's are expensive but have multiple uses (not justified by this app. alone.)
- More work needed to extrapolate to systematic cost (and benefit!)

Not tested (next steps?)

- Are models "good enough" for systematic assessment?
- Can a qualitative "look" at photos (perhaps lower resolution) provide similar results at much lower cost?

Questions/Suggestions?